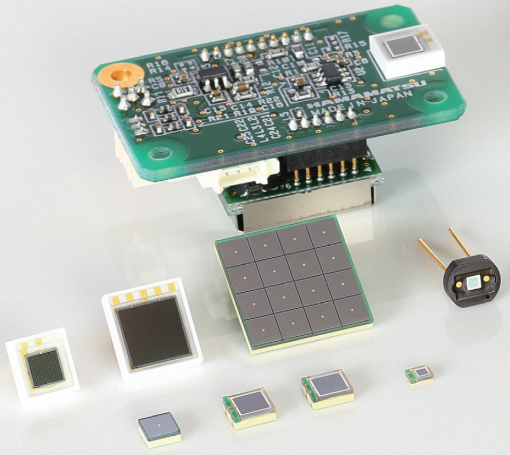
MPPC® and MPPC® module for precision measurement

Low-noise MPPC for precision measurement

MPPCs and MPPC modules for precision measurement inherit the high photon detection efficiency of their predecessors and at the same time provide lower crosstalk, lower afterpulse, and lower dark count.



MPPC®
Multi-Pixel Photon Counter

What is MPPC?

The MPPC (multi-pixel photon counter) is one of the devices called silicon photomultipliers (SiPM). It is a photon-counting device using multiple APD (avalanche photodiode) pixels operating in Geiger mode. Although the MPPC is essentially an opto-semiconductor device, it has excellent photon-counting capability and can be used in various applications for detecting extremely weak light at the photon counting level.

The MPPC operates on low voltage and features high gain, high photon detection efficiency, high-speed response, excellent time resolution, and wide spectral response range. It achieves the performance that is required in photon-counting at a high level. The MPPC is also immune to magnetic fields, highly resistant to mechanical shocks and the like, which are advantages unique to solid-state devices.

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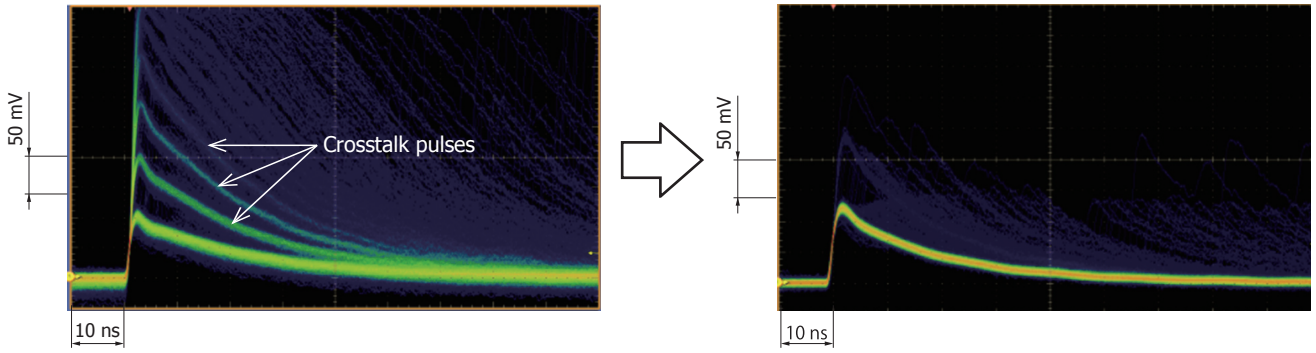
Features of MPPC for precision measurement

When an MPPC detects photons, the output may contain false signals, namely afterpulse and crosstalk, that are separate from the output pulses of the incident photons. The MPPC for precision measurement maintains the high photon detection efficiency while providing low afterpulse, low crosstalk, and low dark count.

Feature 1 Low crosstalk

The pixel that detects photons may affect other pixels, making them produce pulses separate from output pulses. This phenomenon is called crosstalk. The MPPC for precision measurement employs a structure that suppresses the occurrence of crosstalk. This has drastically reduced crosstalk in comparison with previous products (rate of occurrence reduced from 44% to 3%).

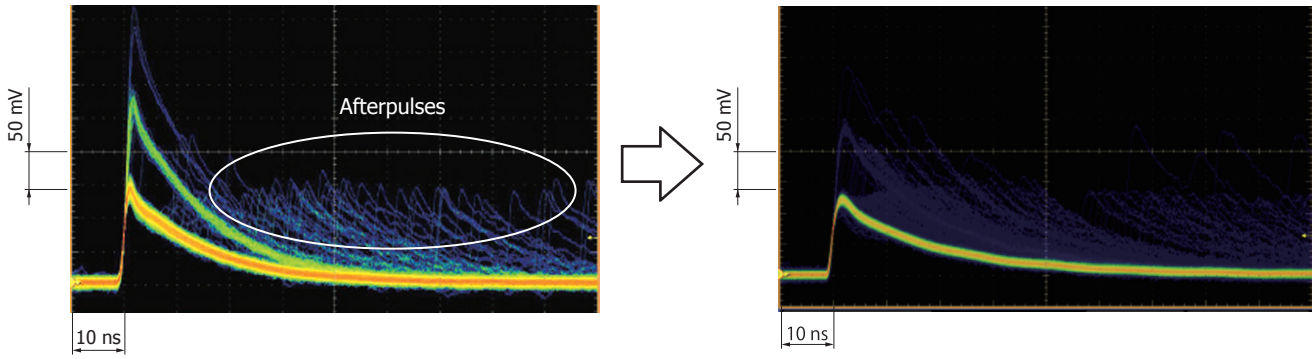
Previous product (3 × 3 mm, 50 µm pitch)	S13360-3050CS (3 × 3 mm, 50 µm pitch)



Feature 2 Low afterpulses

While an MPPC detects photons, delayed signals may be output separately from the output pulses. These signals are called afterpulses. The MPPC for precision measurement provides low afterpulses.

Previous product (3 × 3 mm, 50 µm pitch)	S13360-3050CS (3 × 3 mm, 50 µm pitch)



Feature 3 Low dark count

Improvement in material and wafer process technology has reduced the dark count down to approximately half that of previous products.
See P.3 [▷ Dark count vs. overvoltage].

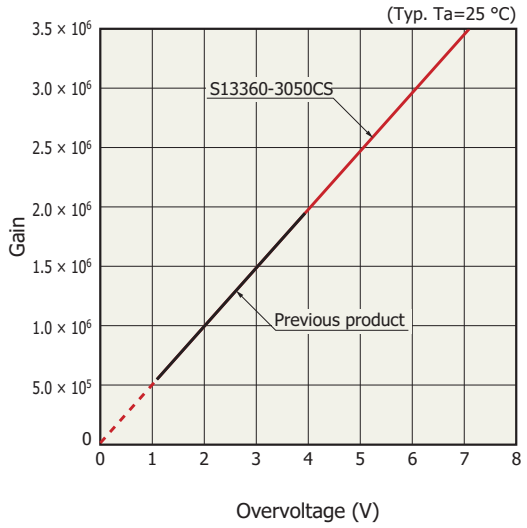
(Typ. Ta=25 °C, 3 × 3mm, Vov=3 V)

Previous product	S13360-3050CS
1 Mcps	0.5 Mcps

Feature 4 Widened operating voltage range

The MPPC operation voltage Vop can be expressed as breakdown voltage (Vbr) + overvoltage (Vov). As the operating voltage is increased, the gain and photon detection efficiency improve, but at the same time, crosstalk and dark count, which are noise components, also increase. With previous products, the voltage dependency of noise components was high, and increasing the operating voltage caused a significant increase in noise components. On the other hand, with the MPPC for precision measurement, increase in noise components is suppressed even when the operating voltage is increased. Therefore, it can be used with high operating voltage (high gain and high photon detection efficiency).

Gain vs. overvoltage



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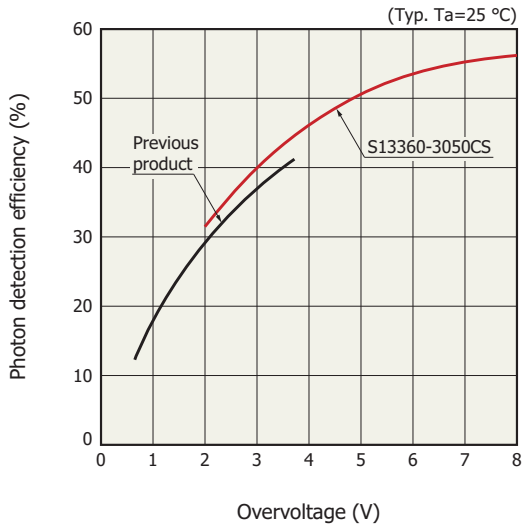
Photon detection efficiency vs. overvoltage



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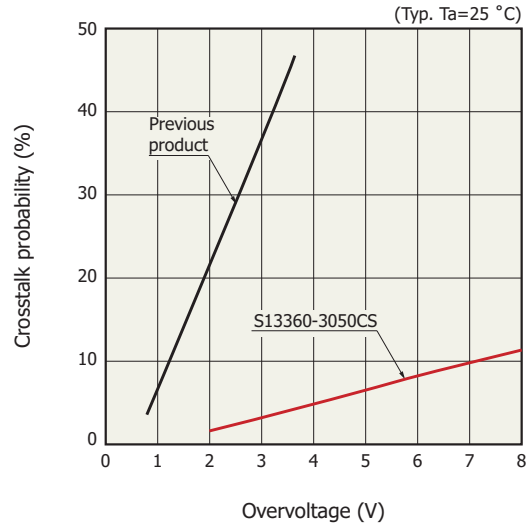
Crosstalk probability vs. overvoltage



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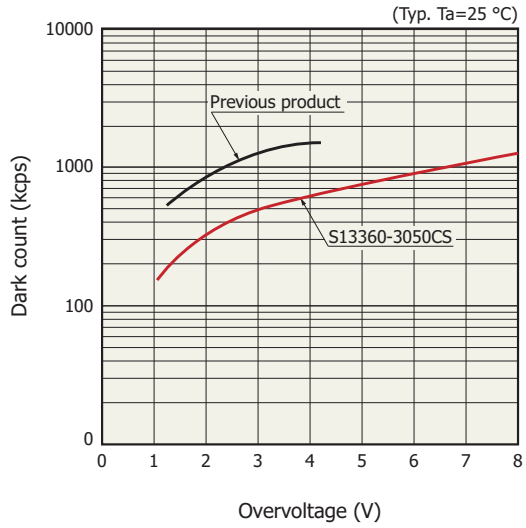
Dark count vs. overvoltage



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Note: Dark pulse overlap (pile-up effect) is eliminated.

Lineup

MPPC modules

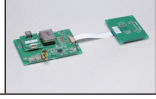
Analog output type

Type no.	Photo	Built-in MPPC	Photosensitive area	Pixel pitch	Photoelectric sensitivity	Noise equivalent power	Temperature control	Supply voltage	See page
C13365-1350SA		S13360-1350CS	□1.3 mm	50 µm	1×10^9	0.5 fW/Hz$^{1/2}$	Temperature compensation (non-cooled)	±5 V	8
C13365-3050SA		S13360-3050CS	□3.0 mm			1.2 fW/Hz$^{1/2}$			
C13366-1350GA		TE-cooled type (MPPC for precision measurement)	□1.3 mm	50 µm		0.1 fW/Hz$^{1/2}$	TE-cooled (-20 °C)	±5 V	9
C13366-3050GA			□3.0 mm			0.15 fW/Hz$^{1/2}$			

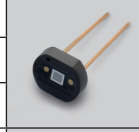
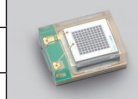
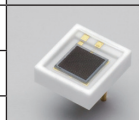
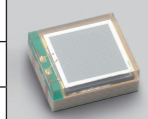
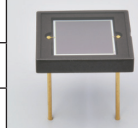
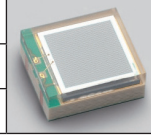
Digital output type

Type no.	Photo	Built-in MPPC	Photosensitive area	Pixel pitch	Photo detection efficiency (%)	Dark count	Temperature control	Supply voltage	See page
C13366-1350GD		TE-cooled type (MPPC for precision measurement)	□1.3 mm	50 µm	40	2.5 kcps	TE-cooled (-20 °C)	±5 V	10
C13366-3050GD			□3.0 mm			15 kcps			

Starter kit

Type no.	Photo	Temperature control	Supply voltage	Features	See page
C12332-01		Temperature compensation (non-cooled)	±5 V	· Evaluates any non-cooled MPPC (sold separately) · Includes C11204-01 power supply for MPPC · Measurable just by setting MPPC operating voltage from PC	21

MPPC

Type no.	Photo	Photosensitive area	Pixel pitch	Package	See page
S13360-1325CS		□1.3 mm	25 µm	Ceramic	12
S13360-1350CS			50 µm		
S13360-1375CS NEW			75 µm		
S13360-1325PE			25 µm	Surface mount type	
S13360-1350PE			50 µm		
S13360-1375PE NEW			75 µm		
S13360-3025CS		□3.0 mm	25 µm	Ceramic	
S13360-3050CS			50 µm		
S13360-3075CS NEW			75 µm		
S13360-3025PE			25 µm	Surface mount type	
S13360-3050PE			50 µm		
S13360-3075PE NEW			75 µm		
S13360-6025CS		□6.0 mm	25 µm	Ceramic	
S13360-6050CS			50 µm		
S13360-6075CS NEW			75 µm		
S13360-6025PE			25 µm	Surface mount type	
S13360-6050PE			50 µm		
S13360-6075PE NEW			75 µm		

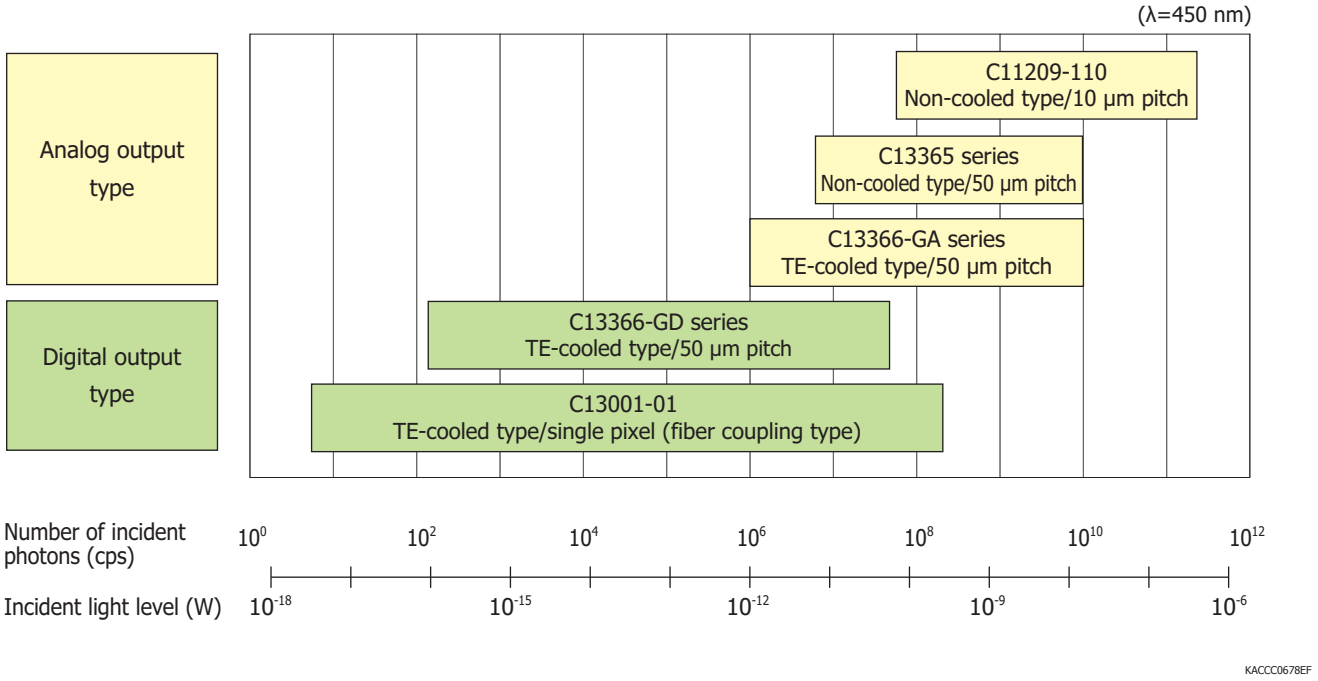
MPPC® module

MPPC module for precision measurement

Hamamatsu provides a full lineup of MPPC modules capable of measuring light over a wide range (10 orders of magnitude) from the photon counting region to nW (nanowatt) region. The modules contain an amplifier, a temperature-compensation circuit, a high-voltage power supply circuit, and other components needed for MPPC operation. You can use them simply by connecting them to a power supply (e.g., ±5 V). Hamamatsu offers a wide lineup of MPPC modules including cooled modules that give a low dark count and non-cooled modules with a temperature compensation function for stable measurement. We can also provide custom products that meet customers' specifications.

Measurable light level range

MPPC modules include two output types according to the incident light level (number of photons): analog output type and digital output type.



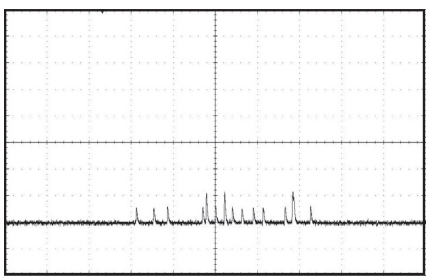
Selecting the digital output type or analog output type

The output type (digital or analog) should be selected according to the light level incident on the MPPC module. The following output waveforms (a) (b) and (c) show MPPC output waveforms measured at different incident light levels and observed on an oscilloscope. The incident light level was increased in the order of (a), (b), and (c), starting from (a) at very low light levels. The output signal of (a) consists of discrete pulses. In this state, selecting the digital output type allows measuring at a higher S/N, where the signals are binarized and the number of pulses is digitally counted. Since the digital output type can easily subtract the dark count from the signal, the detection limit is determined by dark count fluctuations.

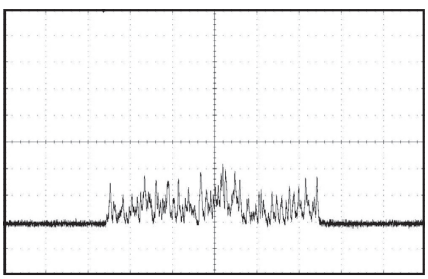
As the light level increases, the output waveform consists of pulses overlapping each other [Figures (b) and (c)]. In this state, the number of pulses cannot be counted and the analog output type should be selected to measure the analog output and find the average value. The detection limit in the analog output type is determined by the dark current shot noise and the cutoff frequency of the readout circuit.

Pulse waveform comparison (typical example)

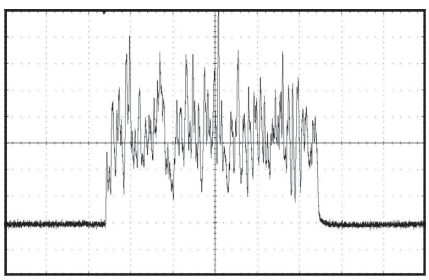
(a) Very low light level



(b) Low light level

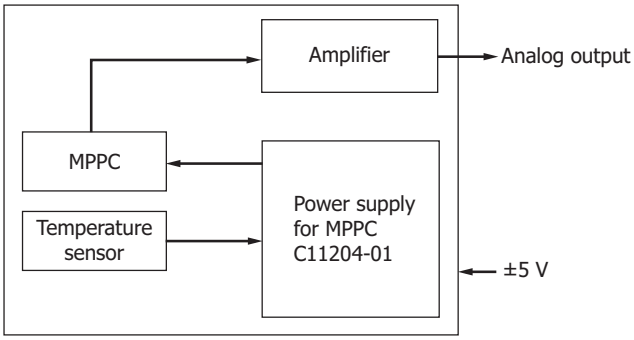


(c) High light level



Block diagram

Analog output type (C13365-1350SA)



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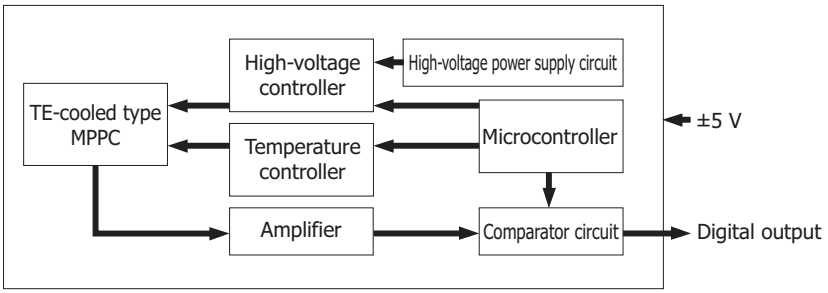
Digital output type (C13366-1350GD)



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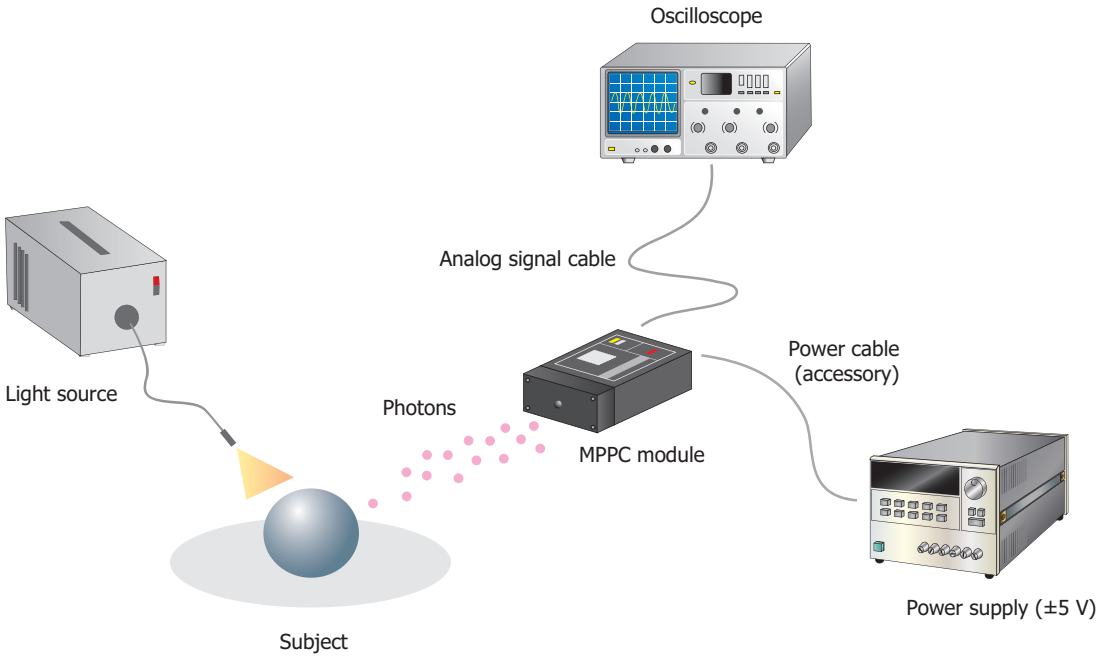
Connection example (C13366-1350GA)



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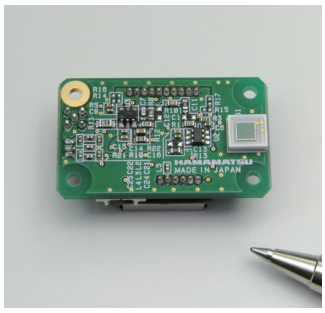
MPPC module

C13365 series

Analog output



Features

- Built-in MPPC for precision measurement
- High sensitivity in the short wavelength range
- Low noise equivalent power
- Built-in temperature compensation function
- Compact and lightweight

Applications

- Flow cytometry
- Low-level light measurement
- Fluorescence measurement

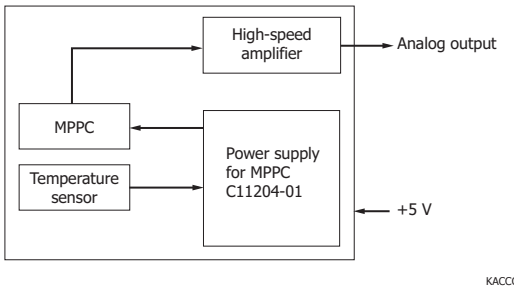
Absolute maximum ratings

Parameter	Symbol	Condition	Value	Unit
Supply voltage	Vs		±6	V
Operating temperature	Topr	No condensation	-20 to +60	°C
Storage temperature	Tstg	No condensation	-20 to +80	°C

Specifications (Typ. Ta=25 °C, λ=λp, Vs=±5 V, unless otherwise noted)

Parameter		Symbol	Condition	C13365-1350SA			C13365-3050SA			Unit
				Min.	Typ.	Max.	Min.	Typ.	Max.	
Spectral response range		λ		270 to 900			270 to 900			nm
Peak sensitivity wavelength		λp		500			500			nm
Effective photosensitive area		-		1.3 × 1.3			3.0 × 3.0			mm
Pixel pitch		-		50			50			μm
Number of pixels		-		667			3600			-
Output voltage stability depending on temperature		-	Ta=25 ± 10 °C	-	-	±5	-	-	±5	%
Photoelectric conversion sensitivity		-		0.7	1.0	1.3	0.7	1.0	1.3	$\times 10^9$ V/W
Cutoff frequency	High band	fc	-3 dB	3.5	5	-	3.5	5	-	MHz
	Low band			DC			DC			-
Noise equivalent power		NEP	Dark state	-	0.5	1.0	-	1.2	2.0	$fW/Hz^{1/2}$
Minimum detection limit		-	Dark state	-	1	2	-	2.7	4.5	pW.r.m.s.
Maximum output voltage		-		4.7			4.7			V
Dimensions (W × D × H)		-		36 × 22 × 12.9						mm

Block diagram



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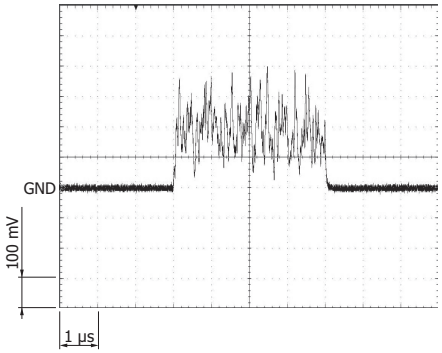
Analog output waveforms



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MPPC module
C13366-GA series

Analog output

Features

- Built-in TE-cooled MPPC (built-in MPPC for precision measurement)
- High sensitivity in the short wavelength range
- Low noise equivalent power
- Built-in temperature control function

Applications

- Low-level light measurement
- Laser microscope
- Flow cytometry
- Fluorescence measurement

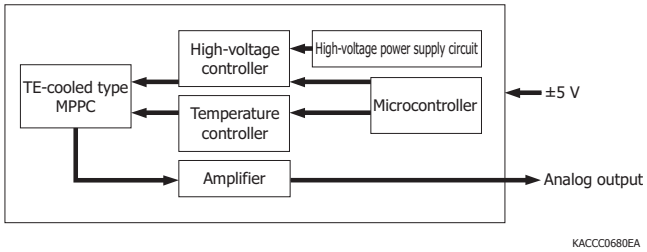
Absolute maximum ratings

Parameter	Symbol	Condition	Value	Unit
Supply voltage	Vs		±6	V
Operating temperature	Topr	No condensation	-10 to +40	°C
Storage temperature	Tstg	No condensation	-20 to +70	°C

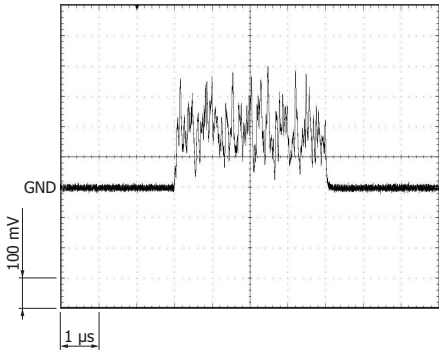
Specifications (Typ. Ta=25 °C, λ=λp, Vs=±5 V, unless otherwise noted)

Parameter		Symbol	Condition	C13366-1350GA			C13366-3050GA			Unit
				Min.	Typ.	Max.	Min.	Typ.	Max.	
Spectral response range		λ		320 to 900			320 to 900			nm
Peak sensitivity wavelength		λp		500			500			nm
Effective photosensitive area		-		1.3 × 1.3			3.0 × 3.0			mm
Pixel pitch		-		50			50			μm
Number of pixels		-		667			3600			-
Element temperature (setting temperature)		Td		-20			-20			°C
Photoelectric conversion sensitivity		-		0.7	1.0	1.3	0.7	1.0	1.3	$\times 10^9$ V/W
Cutoff frequency	High band	fc	-3 dB	3	4	-	3	4	-	MHz
	Low band			DC			DC			-
Noise equivalent power		NEP	Dark state	-	0.1	0.2	-	0.15	0.3	$fW/Hz^{1/2}$
Minimum detection limit		-	Dark state	-	0.25	0.4	-	0.35	0.7	pW.r.m.s.
Maximum output voltage		-		4.7			4.7			V
Dimensions (W × D × H)		-		98 × 60 × 35						mm

Block diagram



Analog output waveforms



MPPC module

C13366-GD series

Digital output

Features

- Built-in TE-cooled MPPC (built-in MPPC for precision measurement)
- High sensitivity in the short wavelength range
- Low crosstalk
- Low dark count
- Low afterpulses

Applications

- Low-level light measurement
- Flow cytometry
- Fluorescence measurement

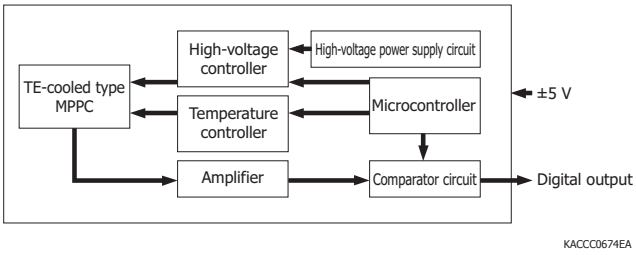
Absolute maximum ratings

Parameter	Symbol	Condition	Value	Unit
Supply voltage	Vs		±6	V
Operating temperature	Topr	No condensation	-10 to +40	°C
Storage temperature	Tstg	No condensation	-20 to +70	°C

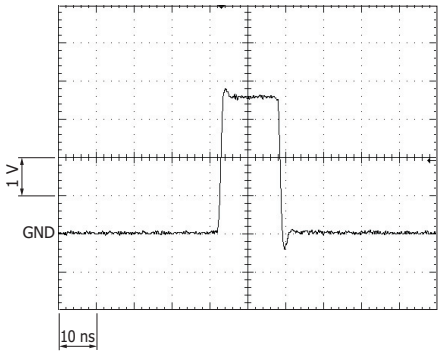
Specifications (Typ. Ta=25 °C, λ=λp, Vs=±5 V, unless otherwise noted)

Parameter	Symbol	Condition	C13366-1350GD			C13366-3050GD			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	
Spectral response range	λ		320 to 900			320 to 900			nm
Peak sensitivity wavelength	λp		450			450			nm
Effective photosensitive area	-		1.3 × 1.3			3.0 × 3.0			mm
Pixel pitch	-		50			50			μm
Number of pixels	-		667			3600			-
Element temperature (setting temperature)	Td		-20			-20			°C
Photon detection efficiency	PDE	Threshold level: 0.5 p.e.	40			40			%
Dark count	-	Threshold level: 0.5 p.e.	-	2.5	7	-	12	36	kcps
Comparator output	-		TTL compatible						-
Afterpulse probability	-	100 ns to 500 ns	-	0.1	-	-	0.1	-	%
Crosstalk probability	-		-	1	-	-	3	-	%
Comparator threshold level	-		0.5 to 8.5 (9 levels, adjustable)						p.e.
Dimensions (W × D × H)	-		98 × 60 × 35						mm

Block diagram



Digital output waveform



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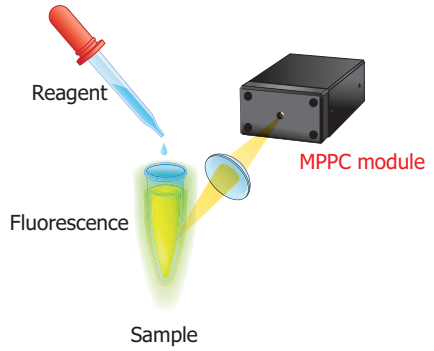
Application examples of MPPC module

Fluorescence measurement



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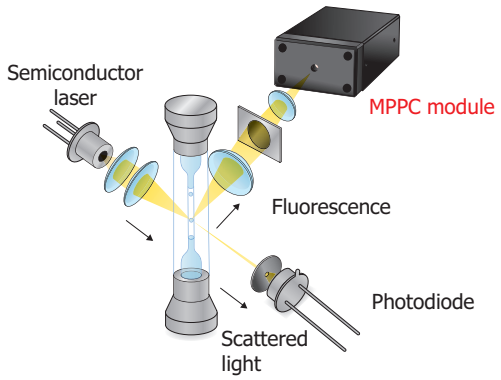
Major characteristics	High photon detection efficiency, low afterpulse
Suitable MPPC modules	C13366-1350GA, C13366-3050GA C13366-1350GD, C13366-3050GD

Flow cytometry



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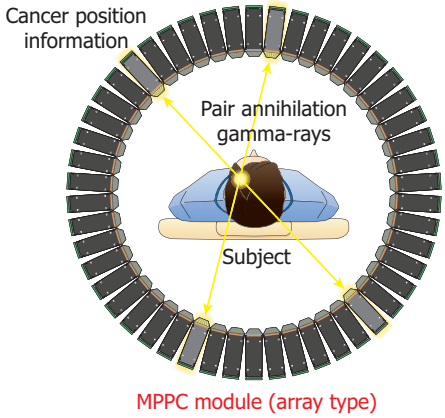
Major characteristics	Wide dynamic range, High photon detection efficiency
Suitable MPPC modules	C13365-1350SA, C13365-3050SA C13366-1350GA, C13366-3050GA

Scintillation measurement



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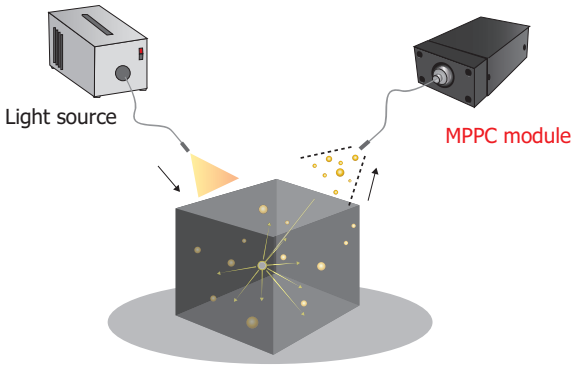
Major characteristics	Wide dynamic range
Suitable MPPC modules	C13365-1350SA, C13365-3050SA

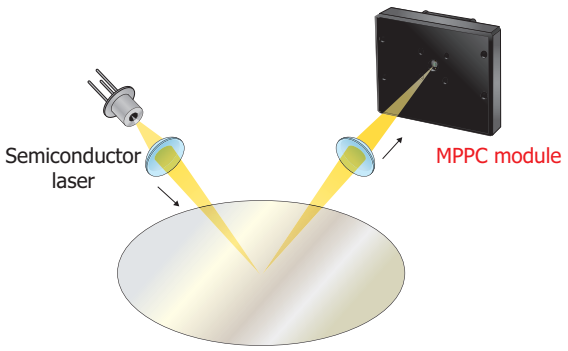
Particle diameter measurement



KACCC0764EA

Major characteristics	Low dark count, low afterpulse
Suitable MPPC modules	C13001-01

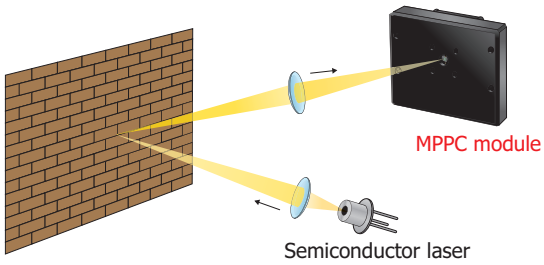
Surface inspection



KACCC0665EB

Major characteristics	High-speed response, wide dynamic range
Suitable MPPC modules	C11209-110

Distance measurement

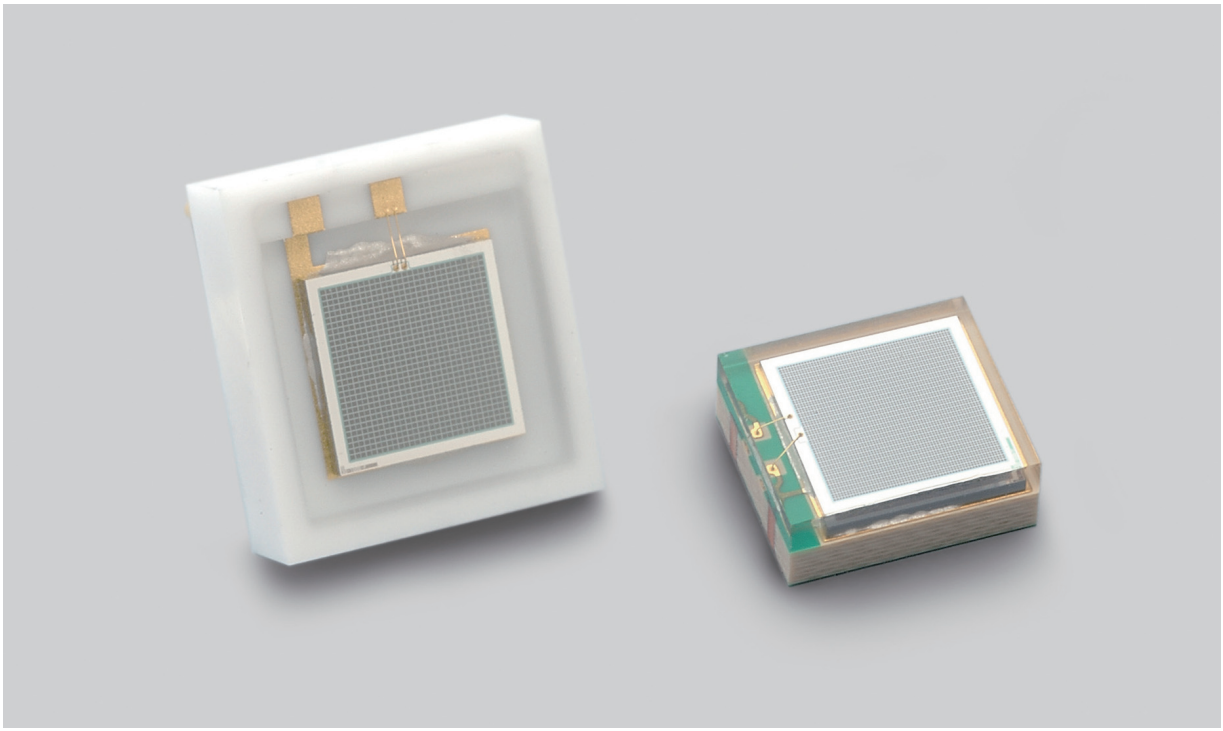


KACCC0666EA

Major characteristics	High-speed response, wide dynamic range
Suitable MPPC modules	C11209-110

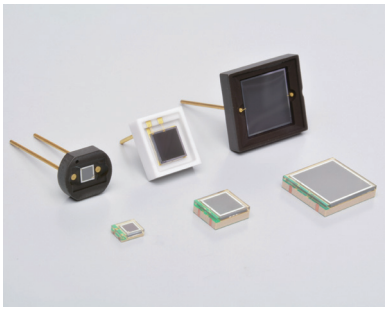
MPPC®

MPPC for precision measurement



MPPC for precision measurement
S13360 series

The S13360 series are MPPCs for precision measurement that inherit the high photon detection efficiency of their predecessors and at the same time provide lower crosstalk, lower afterpulse, and lower dark count. They are suitable for precision measurement, such as flow cytometry, DNA sequencer, laser microscope, and fluorescence measurement, that requires low noise characteristics. They are available in two types: ceramic package and surface mount.



Selection guide

Type no.	Pixel pitch (μm)	Effective photosensitive area (mm)	Number of pixels	Package	Fill factor (%)
S13360-1325CS	25	1.3 × 1.3	2668	Ceramic	47
S13360-1325PE				Surface mount type	
S13360-3025CS		3.0 × 3.0	14400	Ceramic	
S13360-3025PE				Surface mount type	
S13360-6025CS		6.0 × 6.0	57600	Ceramic	
S13360-6025PE				Surface mount type	
S13360-1350CS	50	1.3 × 1.3	667	Ceramic	74
S13360-1350PE				Surface mount type	
S13360-3050CS		3.0 × 3.0	3600	Ceramic	
S13360-3050PE				Surface mount type	
S13360-6050CS		6.0 × 6.0	14400	Ceramic	
S13360-6050PE				Surface mount type	
S13360-1375CS	75	1.3 × 1.3	285	Ceramic	82
S13360-1375PE				Surface mount type	
S13360-3075CS		3.0 × 3.0	1600	Ceramic	
S13360-3075PE				Surface mount type	
S13360-6075CS		6.0 × 6.0	6400	Ceramic	
S13360-6075PE				Surface mount type	

Structure / Absolute maximum ratings

Type no. (package)	Window material	Refractive index of window material	Absolute maximum ratings			
			Operating*1 temperature Topr (°C)	Storage*1 temperature Tstg (°C)	Soldering conditions	Reflow soldering conditions*2 Tsol
S13360-****CS (ceramic)	Silicone resin	1.41	-20 to +60	-20 to +80	350 °C or less, once, within 3 seconds*3	-
S13360-****PE (surface mount type)	Epoxy resin	1.55			-	Peak temperature: 240 °C, twice

*1: No condensation
*2: JEDEC level 5a
*3: Separate by at least 1 mm from the lead root
Note) Exceeding the absolute maximum ratings even momentarilymay cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

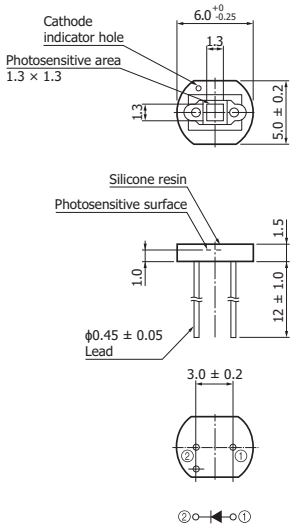
Electrical and optical characteristics (Typ. Ta=25 °C, unless otherwise noted)

Type no.	Measure-ment conditions	Spectral response range λ (nm)	Peak sensitivity wavelength λp (nm)	Photon detection efficiency PDE*1 λ=λp (%)	Dark count*2 Typ. (kcps)	Dark count*2 Max. (kcps)	Terminal capacitance Ct (pF)	Gain M	Break-down voltage VBR (V)	Crosstalk probability (%)	Recommended operating voltage Vop (V)	Temperature coefficient at recommended operating voltage ΔTVop (mV/°C)
S13360-1325CS	Vover =5 V	270 to 900	450	25	70	210	60	7.0×10^5	53 ± 5	1	VBR + 5	54
S13360-1325PE		320 to 900										
S13360-3025CS		270 to 900			400	1200	320					
S13360-3025PE		320 to 900										
S13360-6025CS		270 to 900			1600	5000	1280					
S13360-6025PE		320 to 900										
S13360-1350CS	Vover =3 V	270 to 900		40	90	270	60	1.7×10^6		3	VBR + 3	
S13360-1350PE		320 to 900										
S13360-3050CS		270 to 900			500	1500	320					
S13360-3050PE		320 to 900										
S13360-6050CS		270 to 900			2000	6000	1280					
S13360-6050PE		320 to 900										
S13360-1375CS	Vover =3 V	270 to 900		50	90	270	60	4.0×10^6		7	VBR + 3	
S13360-1375PE		320 to 900										
S13360-3075CS		270 to 900			500	1500	320					
S13360-3075PE		320 to 900										
S13360-6075CS		270 to 900			2000	6000	1280					
S13360-6075PE		320 to 900										

*1: Photo detection efficiency does not include crosstalk or afterpulse.
*2: Threshold=0.5 p.e.
Note: The above characteristics were measured at the operating voltage that yields the listed gain. (See the data attached to each product.)

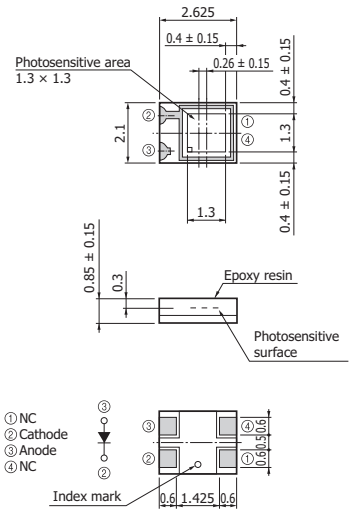
Dimensional outlines (unit: mm)

S13360-1325CS/-1350CS/-1375CS



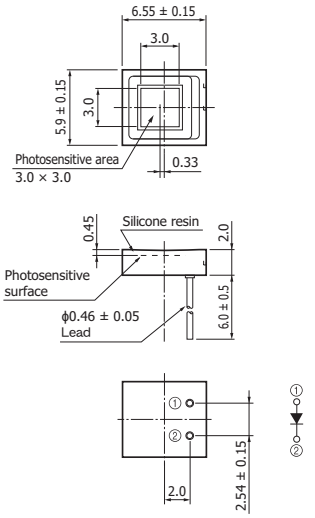
KAPDA0155EA

S13360-1325PE/-1350PE/-1375PE



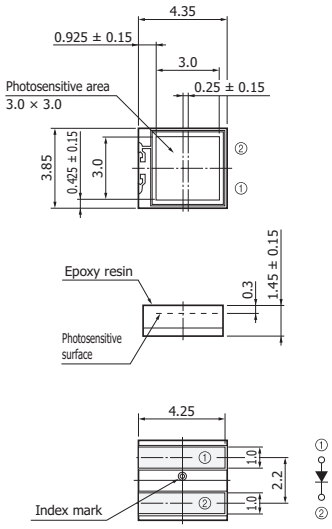
KAPDA0158EA

S13360-3025CS/-3050CS/-3075CS



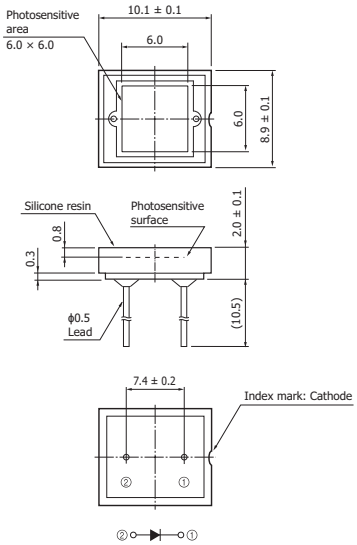
KAPDA0156EA

S13360-3025PE/-3050PE/-3075PE



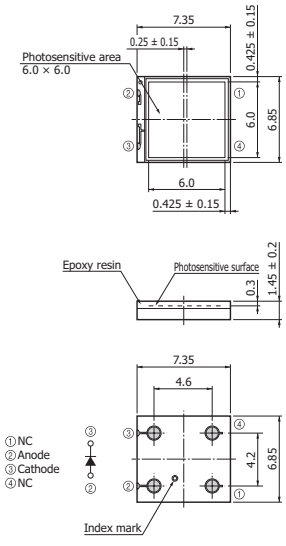
KAPDA0159EA

S13360-6025CS/-6050CS/-6075CS



KAPDA0157EA

S13360-6025PE/-6050PE/-6075PE

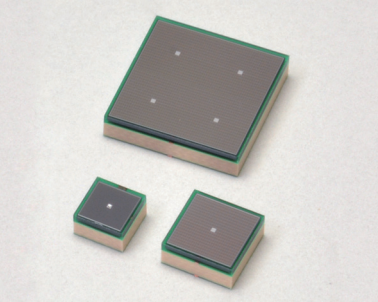


KAPDA0153EA

MPPC for precision measurement (TSV type)

NEW S13360-2050VE/-3050VE/-6050VE

The S13360-2050VE/-3050VE/-6050VE MPPCs employ through-hole electrodes called TSV (through-silicon via). Since no electrode space for wire bonding is needed, the gap (between the package edge and the MPPC photosensitive area) around the outer periphery is reduced to 0.2 mm on the four sides, allowing a four-side buttable arrangement.
The S13360-2050VE/-3050VE/-6050VE are optimized for medical imaging and high-energy particle detection requiring photon counting measurement, as well as other applications involving low-light-level detection.



Selection guide

Type no.	Effective photosensitive area (mm)	Pixel pitch (μm)	Number of pixels (per 1 channel)	Package	Fill factor (%)
S13360-2050VE	2.0 × 2.0	50	1584	Surface mount type	74
S13360-3050VE	3.0 × 3.0		3584		
S13360-6050VE	6.0 × 6.0		14336		

Structure / Absolute maximum ratings

Type no.	Window material	Refractive index of window material	Absolute maximum ratings		
			Operating*1 temperature Topr (°C)	Storage*1 temperature Tstg (°C)	Reflow soldering conditions*2 Tsol
S13360-2050VE	Epoxy resin	1.55	0 to +40	-20 to +60	Peak temperature: 240 °C, twice
S13360-3050VE					
S13360-6050VE					

*1: No condensation
*2: JEDEC level 5a
Note) Exceeding the absolute maximum ratings even momentarilymay cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

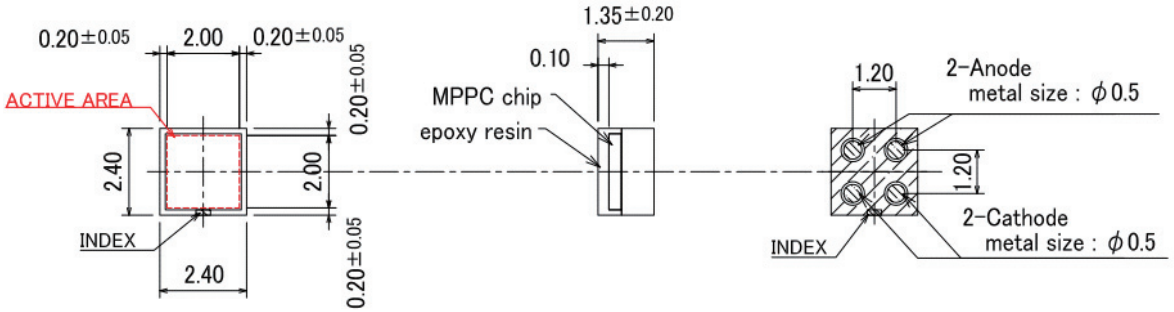
Electrical and optical characteristics (Typ. Ta=25 °C, unless otherwise noted)

Type no.	Measurement conditions	Spectral response range λ (nm)	Peak sensitivity wavelength λp (nm)	Photon detection efficiency PDE*3 λ=λp (%)	Dark count*4		Terminal capacitance Ct (pF)	Gain M	Break-down voltage V_{BR} (V)	Recommended operating voltage Vop (V)	Temperature coefficient at recommended operating voltage ΔTVop (mV/°C)
					Typ. (kcps)	Max. (kcps)					
S13360-2050VE	Vover =5 V	320 to 900	450	40	220	660	140	1.7×10^6	53 ± 5	V_{BR} + 3	54
S13360-3050VE					500	1500	320				
S13360-6050VE					2000	6000	1280				

*3: Photo detection efficiency does not include crosstalk or afterpulse.
*4: Threshold=0.5 p.e.
Note: The above characteristics were measured at the operating voltage that yields the listed gain. (See the data attached to each product.)

Dimensional outlines (unit: mm)

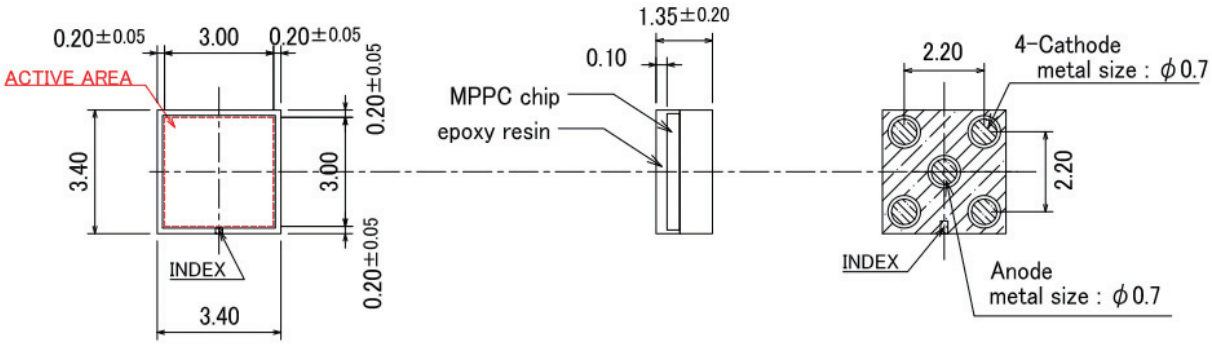
S13360-2050VE



ACTIVE AREA SIZE: 2.0mm x 2.0mm
MPPC CHIP SIZE : 2.1mm x 2.1mm

GENERAL TOLERANCE : ±0.1

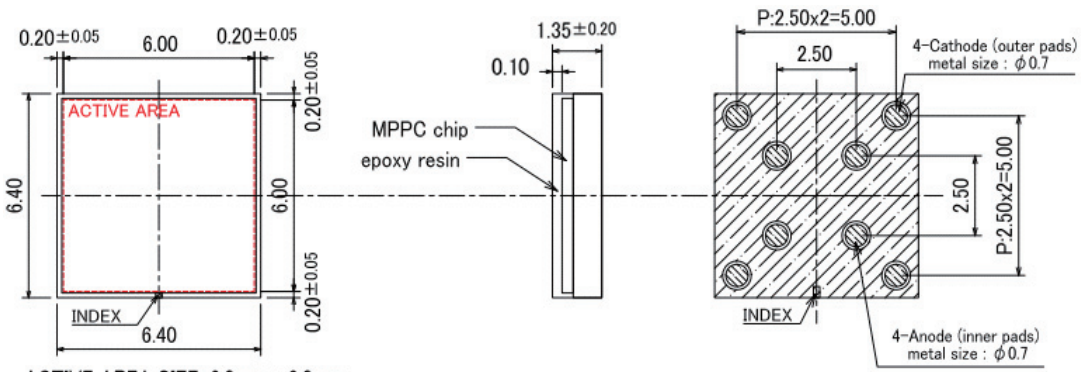
S13360-3050VE



ACTIVE AREA SIZE: 3.0mm x 3.0mm
MPPC CHIP SIZE : 3.1mm x 3.1mm

GENERAL TOLERANCE : ±0.1

S13360-3050VE



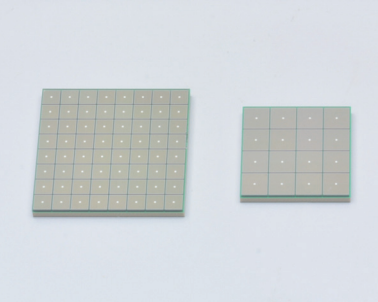
ACTIVE AREA SIZE: 6.0mm x 6.0mm
MPPC CHIP SIZE : 6.1mm x 6.1mm

GENERAL TOLERANCE : ±0.1

MPPC array for precision measurement

NEW S13361 series

The S13361 series MPPC arrays employ through-hole electrodes called TSV (through-silicon via). The pitch of each MPPC channel is 3.2 mm.
The S13361 series is optimized for medical imaging and high-energy particle detection requiring photon counting measurement, as well as other applications involving low-light-level detection.



Selection guide

Type no.	Effective photosensitive area (mm)	Number of channels	Pixel pitch (μm)	Number of pixels (per 1 channel)	Package	Fill factor (%)
S13361-2050NE-04	2.0 × 2.0	16 (4 × 4)	50	1584	Surface mount type	74
S13361-2050AE-04					Connector*1	
S13361-3050NE-04	3.0 × 3.0	16 (4 × 4)		3584	Surface mount type	
S13361-3050AE-04					Connector*1	
S13361-3050NE-08		64 (8 × 8)			Surface mount type	
S13361-3050AE-08					Connector*1	
S13361-6050NE-04	6.0 × 6.0	16 (4 × 4)		14336	Surface mount type	
S13361-6050AE-04					Connector*1	

*1: A connector made by SAMTEC is mounted on the back side of the board.
ST4-10-1.00-L-D-P-TR (S13361-2050NE/AE-04)
ST4-20-1.00-L-D-P-TR (S13361-3050NE/AE-04)
ST4-40-1.00-L-D-P-TR (S13361-3050NE/AE-08, S13361-6050NE/AE-04)
These connectors mate with a SAMTEC receptacle (SS4-10-3.00-L-D-K-TR, SS4-20-3.00-L-D-K-TR, or SS4-40-3.00-L-D-K-TR).
See the following URL for detailed information.
http://www.samtec.com/ftppub/pdf/ss4.pdf

Structure / Absolute maximum ratings

Type no.	Window material	Refractive index of window material	Absolute maximum ratings		
			Operating*2 temperature Topr (°C)	Storage*2 temperature Tstg (°C)	Reflow soldering conditions*3 Tsol
S13361-2050NE-04	Epoxy resin	1.55	-20 to +60	-20 to +80	Peak temperature: 240 °C, twice
S13361-2050AE-04					
S13361-3050NE-04			0 to +40	-20 to +60	
S13361-3050AE-04					
S13361-3050NE-08					
S13361-3050AE-08					
S13361-6050NE-04					
S13361-6050AE-04					

*2: No condensation
*3: JEDEC level 5a
Note: Exceeding the absolute maximum ratings even momentarilymay cause a drop in product quality. Always be sure to use the product within the absolute maximum ratings.

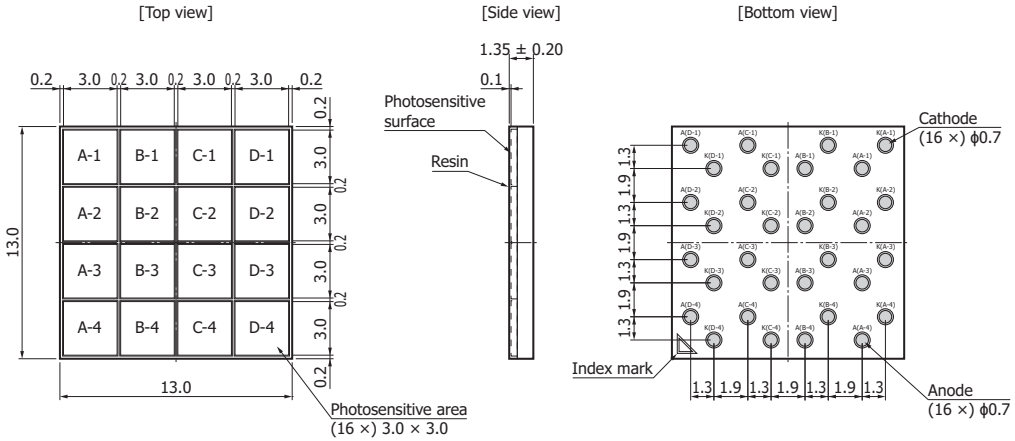
Electrical and optical characteristics (Typ. Ta=25 °C, unless otherwise noted)

Type no.	Measurement conditions	Spectral response range λ (nm)	Peak sensitivity wavelength λp (nm)	Photon detection efficiency PDE*4 λ=λp (%)	Dark count*5 Typ. (kcps)	Dark count*5 Max. (kcps)	Terminal capacitance Ct (pF)	Gain M	Break-down voltage VBR (V)	Recommended operating voltage Vop (V)	Temperature coefficient at recommended operating voltage ΔTVop (mV/°C)
S13361-2050NE-04	Vover =5 V	320 to 900	450	40	500	1500	320	1.7×10^6	53 ± 5	VBR + 3	54
S13361-2050AE-04											
S13361-3050NE-04											
S13361-3050AE-04											
S13361-3050NE-08											
S13361-3050AE-08											
S13361-6050NE-04											
S13361-6050AE-04											

*4: Photo detection efficiency does not include crosstalk or afterpulse.
*5: Threshold=0.5 p.e.
Note: The above characteristics were measured at the operating voltage that yields the listed gain. (See the data attached to each product.)

Dimensional outlines (unit: mm)

S13361-3050NE-04



Tolerance: ±0.1 unless otherwise noted
* A (X-Y): Anode pad of (X-Y) channel.
K (X-Y): Cathode pad of (X-Y) channel.

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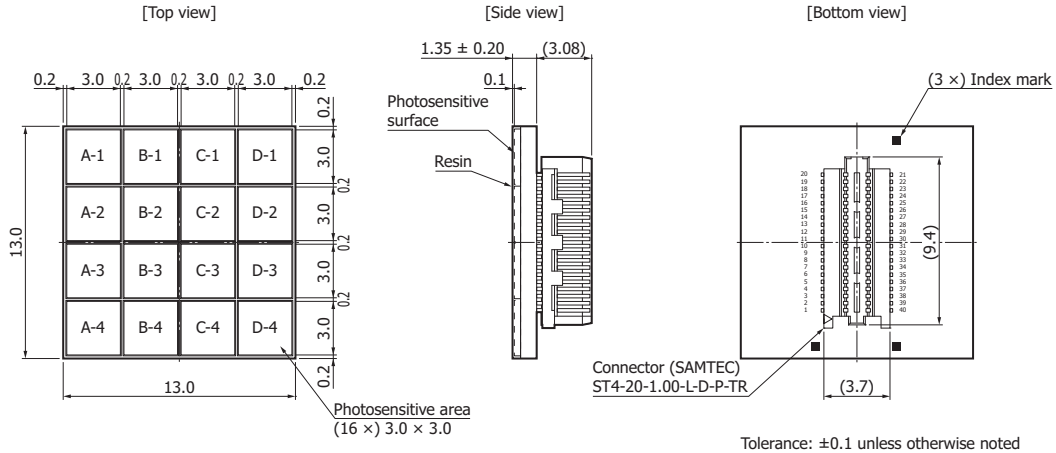
S13361-3050AE-04



Tolerance: ±0.1 unless otherwise noted

KAPDA0169EA

Other MPPC product

Other MPPC and MPPC module

The product lineup containing MPPCs for general measurement (low afterpulse) is provided below.

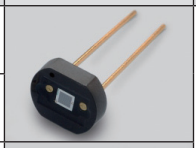
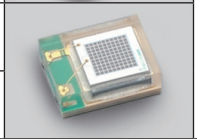
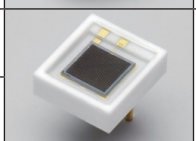
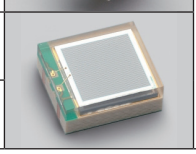
MPPC modules

Type no.	Photo	Effective photosensitive area	Pixel pitch	Temperature control	Output
C11209-110		□1.0 mm	10 µm	Temperature compensation (non-cooled)	Analog
C13001-01		Single pixel ϕ50 µm (fiber coupling type)		TE-cooled (-20 °C)	Digital

MPPC array modules

Array modules are available in various types. Contact us for detailed information.

MPPC for general measurement

Type no.	Photo	Photosensitive area	Pixel pitch	Package
S12571-010C		□1.0 mm	10 µm	Ceramic
S12571-015C			15 µm	
S12571-010P			10 µm	Surface mount type
S12571-015P			15 µm	
S12572-010C		□3.0 mm	10 µm	Ceramic
S12572-015C			15 µm	
S12572-010P			10 µm	Surface mount type
S12572-015P			15 µm	

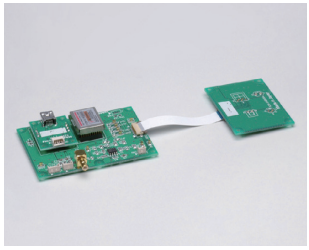
Related product

Starter kit for MPPC C12332-01

This is a starter kit for evaluating the MPPC. It consists of a power supply circuit board and a sensor circuit board. The power supply circuit board is equipped with a C11204-01 power supply for MPPC. The sensor circuit board has an MPPC socket with leads, which allows various non-cooled MPPCs to be implemented.

Features

- Enables the evaluation of non-cooled MPPCs (sold separately)
- Comes with a socket for an MPPC
  Connection possible MPPC with flexible cable
- Equipped with a high-accuracy, high-voltage C11204-01 power supply
- Adjustable operating voltage and temperature compensation coefficient
- Selectable amplifier usage
- Load resistance 50 Ω or 1 kΩ selectable
- Analog output

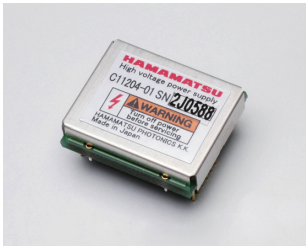


C11204-01 power supply for MPPC

This is a high voltage power supply that is optimized for driving MPPCs. Since it has a temperature compensation function, MPPCs can be driven stably even in environments subject to temperature changes.

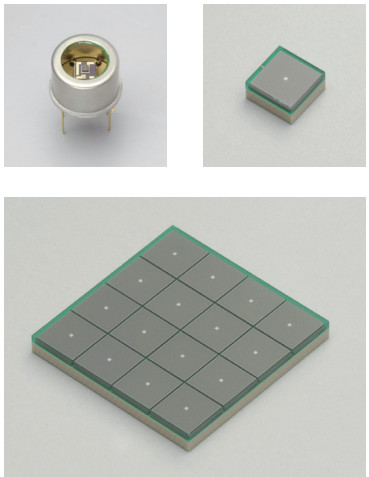
Features

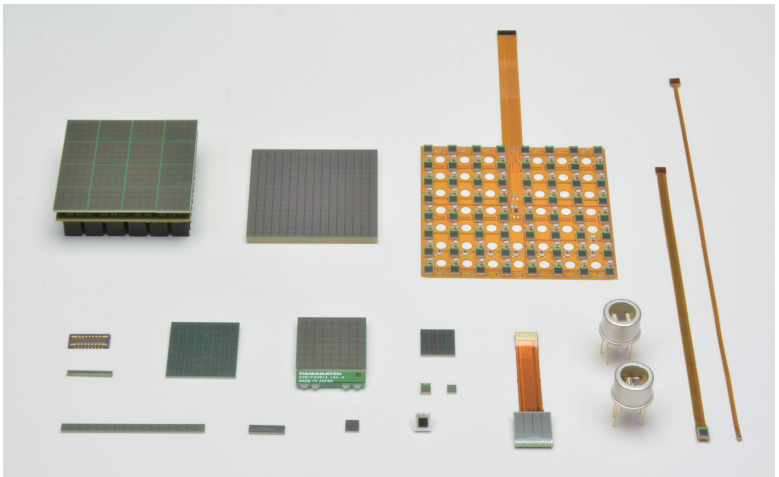
- Wide output voltage range: 50 V to 90 V
- Low ripple noise: 0.1 mVp-p typ.
- Superb temperature stability: ±10 ppm/°C typ.
- High resolution settings (1.8 mV resolution)
- Serial interface



Customized MPPC module

Hamamatsu Photonics can provide the most suitable module product by combining its vast MPPC lineup with optical technologies, circuit technologies, and software technologies. Contact us for detailed information.





Principle of operation

Photon counting

Light has the properties of both a particle and a wave. When the light level becomes extremely low, light behaves as discrete particles (photons) allowing us to count the number of photons. Photon counting is a technique for measuring the number of individual photons.

The MPPC is suitable for photon counting since it offers an excellent time resolution and a multiplication function having a high gain and low noise. Compared to ordinary light measurement techniques that measure the output current as analog signals, photon counting delivers a higher S/N and higher stability even in measurements at very low light levels.

Geiger mode and quenching resistor

When an APD is operated at a reverse voltage higher than the breakdown voltage, a saturated output inherent to the APD device occurs (Geiger discharge) by input of light regardless of whether the light level is high or low. The condition where an APD operates at this voltage level is called Geiger mode. Geiger mode allows obtaining a large output by way of discharge even when detecting a single photon. Once Geiger discharge begins, it continues for as long as the electric field in the APD is maintained.

To halt a Geiger discharge and detect the next photon, an external circuit outside the APD must lower the operating voltage. One specific example for halting the Geiger discharge is a technique using a so-called quenching resistor connected in series with the APD. This quickly stops avalanche multiplication in the APD because a drop in the operating voltage occurs when the output current caused by the Geiger discharge flows in the quenching resistor. The output current caused by Geiger discharge is a pulse waveform with a sharp rise time, while the output current when Geiger discharge is halted by the quenching resistor is a pulse waveform with a relatively slow fall time [Figure 5].

Structure

The MPPC structure is shown in the following figure. The basic element (pixel) of an MPPC is a combination of the Geiger mode APD and quenching resistor, and a large number of these pixels are electrically connected and arranged in two dimensions.

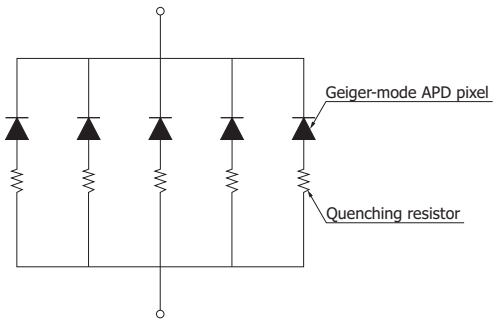


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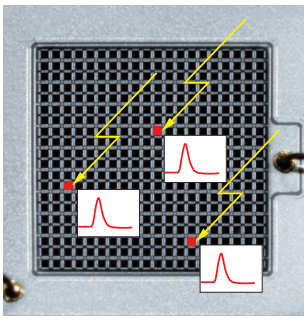
Image of MPPC's photon counting



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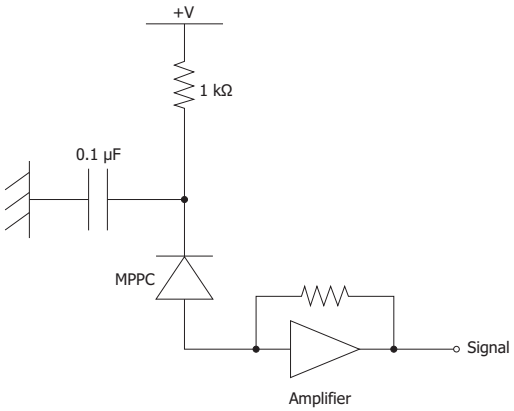
Basic operation

Each pixel in the MPPC outputs a pulse at the same amplitude when it detects a photon. Pulses generated by multiple pixels are output while superimposed onto each other. For example, if four photons are incident on different pixels and detected at the same time, then the MPPC outputs a signal whose amplitude equals the height of the four superimposed pulses.

Each pixel outputs only one pulse and this does not vary with the number of incident photons. So the number of output pulses is always one regardless of whether one photon or two or more photons enter a pixel at the same time. This means that MPPC output linearity gets worse as more photons are incident on the MPPC such as when two or more photons enter one pixel. This makes it essential to select an MPPC having enough pixels to match the number of incident photons.

Basic connection diagram



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For the MPPC readout circuit, a current-to-voltage amplifier can be used as with previous semiconductor devices. The MPPC outputs high-speed pulse signals, but because the gain of the MPPC itself is high, there is no need to greatly increase the gain on the circuit side. This has an advantage that there is more freedom in circuit design.

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